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INVISIBLE STARLIGHT[1]

By Dr. PAUL W. MERRILL

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INVISIBLE radiation was first observed when Sir William Herschel, in 1800, found a blackened thermometer bulb to be warmed when placed beyond the red end of the sun's visible spectrum. The following year, J. W. Ritter noted the darkening of silver chloride caused by light beyond the *violet* end of the solar spectrum. Three quarters of a century elapsed before the study of invisible starlight was begun by Sir William Huggins, who, in 1876, photographed both visible and ultra-violet stellar spectra. Although of obvious interest, the investigation of invisible starlight has developed slowly, not only because of serious practical difficulties but because it was natural and proper to exploit first the more readily observed visible portion of the spectrum. The time has now come, however, when astronomers can perhaps afford to devote more attention to ultra-violet and infra-red light. Hence it may be worth while to outline the general importance of invisible starlight in astrophysical investigations and to review the present observational status of the problem.

To obtain a general view of the situation let us consider first radiation as it leaves the star; then what happens to it in interstellar space and in the earth's atmosphere; and finally what can be done with it when it arrives at the focus of a telescope. The original investigators had, of course, to work the sequence in the opposite direction.

The most important property of the light emitted by any incandescent object is the manner in which the energy is distributed among various wave-lengths—briefly, its spectral intensity curve. Laboratory investigations have shown that for most solid or liquid bodies the curve has a definite relationship to the

[1] Address of the retiring vice-president and chairman of the Section of Astronomy, American Association for the Advancement of Science, Boston, December, 1933.

temperature of the source, expressed by Planck's equation for a so-called black body or complete radiator. It is well known that incandescent gases in very thick layers radiate much like solid bodies, and there is good reason to believe that we may use the equation to calculate the general properties of starlight. The conclusions in the following paragraph are based largely on this premise.

The position of maximum intensity in the spectrum depends on the temperature of the star's visible surface. For the low-temperature stars (red in color) the maximum is in the infra-red; for stars of intermediate temperature, such as the sun, it is in the visible region; while for the hotter stars, like Rigel and certain other stars in the constellation Orion, it shifts into the ultra-violet. At any temperature the intensities drop rapidly on the short wave-length side of the maximum, more gradually on the long wave-length side. What wave-length range should be observed in order to include important stellar radiations? To answer this question let us assume that for any star we desire the observations to cover all points in the spectrum where the energy exceeds 10 per cent. of that at the maximum. It will be sufficient to make computations for temperatures 2,000° and 20,000° C. because the vast majority of stars have effective temperatures between these limits. For the hotter stars the maximum lies at 1450 Å, the 10 per cent. limit on the short wave-length side at 620 Å; for the cooler stars the maximum is at 14,500 Å, the 10 per cent. limit on the long wave-length side at 48,000 Å. Thus for a really complete knowledge of stellar spectra we should be able to observe from 600 Å to 50,000 Å; even to cover the maxima of various stellar spectra would require a range exceeding 1450 Å to 14,500 Å.

Except for general attrition caused by its struggle with the inverse square law, not much happens to starlight in its long passage through the abysmal depths of interstellar space. To a degree of approximation which is probably very high, except for extremely remote objects, starlight has the same properties when it strikes the earth's atmosphere that it had when it left the star. The relatively minor losses suffered through absorption and scattering in interstellar space and the reddening of light from distant galaxies, although of great interest, are not discussed here.

We are forced to study the stars from the bottom of a great ocean of air many miles deep. What this ocean does to starlight constitutes the next chapter of the story.

What it does to the more refrangible (ultra-violet) end of the spectrum is a crime. It shuts off completely all wave-lengths shorter than 2950 Å—over two octaves. This limit appears to be set by certain powerful ozone bands, and, as ozone is especially abundant in the upper atmosphere, ascending a mountain does not appreciably extend the observable range of wave-lengths. As far as we can see now, therefore, these important short wave-length stellar radiations are forever inaccessible to us unless we can establish an observing station beyond the earth's atmosphere, say on the moon. An alternative is the use of a rocket to carry a spectrograph beyond the atmosphere. Studying starlight by such an apparatus can not be contemplated with optimism at present; it even stretches the imagination to consider its application to sunlight.

The situation at the other end of the visible spectrum is not so hopeless: the long wave-lengths are mutilated but not annihilated. Figure 1 shows the

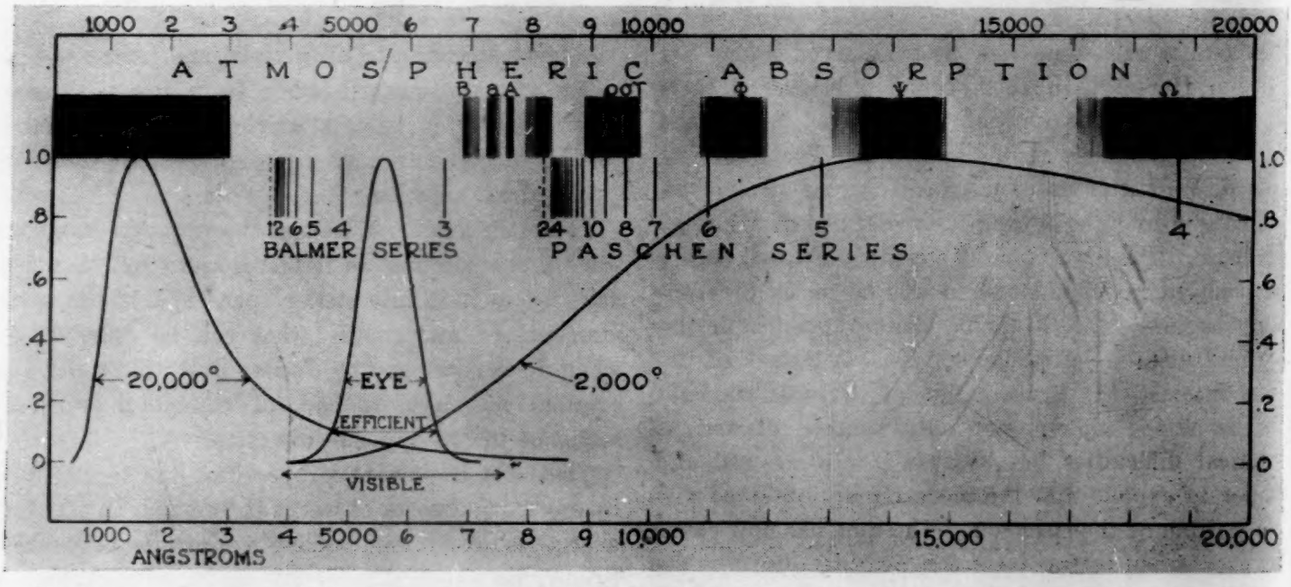

FIG. 1. Spectral intensity curves of "black-body" radiation at 2,000° and 20,000° C. compared with the visibility curve of the eye. Above: the regions of atmospheric absorption, and the positions of lines in the Balmer and Paschen series of hydrogen.

ultra-violet barrier and the regions in the near infra-red that are subject to strong absorption.

The human eye is sensitive to a band of wave-lengths—corresponding to the colors of the visible spectrum—which comprises but a small fraction of the range of wave-lengths of astrophysical importance. Fig. 1 compares the visibility curve of the eye with the spectral energy curves of stars at 2,000° and 20,000°, respectively. Notice to what a slight extent the curves overlap. Visible light extends from about 3900 Å to 7600 Å (further in both directions for very high intensities). Beyond 4740 Å on the violet side, and 6500 Å on the red side, however, the efficiency of the average eye is less than 10 per cent. of its maximum efficiency, which falls at 5600 Å in the green. The diagram also shows the very considerable regions transmitted by the atmosphere, which make no impression on the eye. In these regions the astronomer can study invisible starlight. It is an interesting fact that the visible wave-lengths lie near the geometrical mean of the limits of important radiation from the stars. The following small table, taken from computations by L. L. Holladay, shows for the two temperatures the percentages of black body radiation in various spectral regions.

PERCENTAGES OF BLACK BODY RADIATION IN VARIOUS SPECTRAL REGIONS

Temp.	Far U. V. 0 to 3000 Å	Near U.V. 3000 to 4000 Å	Visible 4000 to 7600 Å	Infra-Red 7600 Å to ∞
2,000°	0.0	0.0	1.4	98.6
20,000°	73.9	11.8	11.3	3.0

No thoughtful person will consider the fact that our atmosphere is transparent to those radiations which the eye uses in vision to be a mere coincidence; adaptation is surely indicated. Moreover, it is highly convenient that most solid objects be opaque to these same wave-lengths. X-rays penetrate both air and solids and would serve poorly for vision. Now what shall we say of the additional fact that the most intense radiations of our principal light giver, the sun, lie in the range of high visual efficiency? Adaptation is again indicated. We may, however, propose the following question: How did the human race select for its abode a planet whose atmosphere is transparent to the most important rays of the light-giving body about which the planet revolves?

The first observations of stellar spectra were of course made visually. Not until the successful application of photography in 1876 by the astrophysical pioneer, Sir William Huggins, could any of the ultra-violet be included. The most striking ultra-violet features shown by his photographs (the published reproductions of which extend to 3300 Å) were the numerous hydrogen lines extending the Balmer series to a far greater number of members than previously known. The great importance of the H and K lines of ionized calcium was also clearly brought out. Huggins found at once a definite limit in the ultra-violet and, correctly ascribing it to the action of the earth's atmosphere, explained the situation in the following words:

> There is little doubt that in stars of the white-star class, and many of the solar class, the star's light is limited in its extension into the ultra-violet alone by the absorption of our atmosphere, as I found to be the case with the light of α Cygni; however prolonged the exposure, the spectrum of this star stopped upon the plate at about the place which Cornu had found to be the limit imposed upon solar light by atmospheric absorption—namely, at about λ2970. The light of Vega, at my Observatory (which has an elevation of 177 feet), with the barometer at about 30 inches, was abruptly weakened at λ3000 and then continuing very faint, was apparently extinguished at λ2970.
>
> Within this limit, imposed upon all celestial light by our atmosphere, the character and strength of the ultra-violet region of the spectra of stars will be of the first importance in any discussion of the classification of the stars founded upon the hypothesis of an evolutional progress.

Huggins' apparatus was especially adapted to the efficient recording of ultra-violet light. His Cassegrain telescope had speculum metal mirrors, while the spectrograph was equipped with calcite prisms and quartz lenses.

In modern apparatus the two great hindrances to the observation of ultra-violet starlight are the opacity of the glass employed and the transparency of silver. A trace of iron makes optical glass, especially that containing lead (flint glass), transmit very poorly in the ultra-violet. In general, the denser the glass, the higher the dispersion and the smaller the ultra-violet transmission. The types of flint glass commonly used for prisms in astronomical spectrographs cut down the light seriously at 4000 Å and prevent, without considerably increased exposure times, extension of the spectra past 3900 Å. Quartz is beautifully clear in this region, and certain recently developed types of ultra-violet glass combine high transparency with fair dispersion. Gratings may, of course, be used in the ultra-violet, but so far have not been found to compete well with prisms, except for high dispersion.

Reflecting telescopes are free from the absorption introduced by the lens of the refractor, but the ordinary silver-on-glass mirror has a difficulty peculiar

to itself, and one which has set the ultra-violet limit of spectroscopic observations with modern reflecting telescopes. A curious property of a thin silver film, such as that deposited on an astronomical mirror, is that, although almost perfectly opaque and highly reflecting to visual light, it has a transmission band near 3200 Å. Starlight of this wave-length, therefore, shines right through the silvered surface of an astronomical mirror and is not returned with the other light to the focus. The limit thus set is shown by the fact that W. H. Wright, using an efficient ultra-violet spectrograph in connection with the Crossley silver-on-glass reflector at the Lick Observatory, was able to photograph the spectrum of α Cygni only as far as 3245 Å.

Speculum metal, formerly widely used for astronomical mirrors, is more uniformly reflective in the ultra-violet than silver. More modern substitutes are chromium or aluminum. Mirrors with surfaces of one of these metals should make possible photographs of stellar spectra out to the limit set by the atmosphere.

The first agency to explore the infra-red of stellar spectra as well as of the solar spectrum was not photography, but an energy-measuring device equally sensitive to all wave-lengths. Moreover, an instrument of this kind is able to tell us something of wave-lengths much longer than anything the photographic plate can as yet record. It will be convenient, however, to speak first of what has been accomplished by photography in the near infra-red.

The first photographs of stellar spectra, as already mentioned, were limited to the blue-violet region to which alone the older emulsions were sensitive. Later the application of photo-sensitizing dyes, notably erythrosin, pinacyanol and dicyanin, made possible the inclusion of longer wave-lengths. For a number of years preceding 1920, stellar spectrograms were frequently made on ordinary emulsions sensitized shortly before exposure by staining with one or more dyes. Since 1920 commercial panchromatic plates, in which the dye is incorporated in the emulsion before coating, have been greatly improved, and are now very satisfactory for the region from 5000 Å to 6800 Å. For exposures to stellar spectra they are usually hyper-sensitized by a preliminary bath in dilute ammonia.

Before 1930, special photographic emulsions were available for the extreme red and near infra-red, but they were relatively insensitive, and considerable difficulty was experienced in obtaining useful stellar spectrograms beyond about 7000 Å. A few photographs, however, were made by V. M. Slipher, J. Bosler, W. H. Wright and P. W. Merrill on plates sensitized with dicyanin, kryptocyanin or neocyanin.

The recent discovery and systematic testing of new dyes, particularly by the Research Laboratory of the Eastman Kodak Company, has resulted in greatly improved emulsions for the longer wave-lengths, and it is now possible to obtain, with moderate exposure times, satisfactory stellar spectrograms extending into the infra-red as far as 9000 Å.

In the region from 7000 to 9000 Å, lines of the earth's atmosphere are numerous and intense and interfere considerably with the observations of stellar lines. There are, nevertheless, many features of interest, especially in the clear region 8320–8900 Å. Photographs of this region have recently been made at Mount Wilson with a small grating spectrograph attached to the 100-inch telescope. No effort was made to penetrate the dense group of atmospheric lines, beginning about 8950 Å, for, although feasible to do so, the study of stellar features would be handicapped by the intense and closely packed telluric lines. With zenocyanin plates it does not appear impossible to extend stellar observations beyond the end of this group at 9800 Å, but this has not yet been attempted.

Among the interesting features photographed in the near infra-red of stellar spectra may be mentioned the Paschen series of hydrogen lines; the great triplet of ionized calcium, λλ8498, 8542, 8662; neutral oxygen lines, λλ7771–4–5, 8446; cyanogen absorption in N-type spectra.

According to the quantum theory, a hydrogen atom must reside in one of the so-called stationary states whose energies exhibit a regular progression in inverse proportion to the squares of integers from one to infinity. Series of spectral lines are formed by transitions between any level and the succession of higher levels. Physicists have observed and named the first five series:

SERIES OF HYDROGEN LINES

Lower level	Location in spectrum	Name
1	1,200– 900 Å	Lyman series
2	7,000– 3,600 "	Balmer series
3	19,000– 8,200 "	Paschen series
4	41,000–15,000 "	Brackett series
5	74,000–23,000 "	Pfund series

The Lyman series lies entirely in the far ultra-violet inaccessible in stellar spectra while the Brackett and Pfund series are deep in the infra-red, where present methods are inadequate to record lines in stellar spectra. The Balmer series is favorably situated and has been so extensively studied since the days of Sir William Huggins that its behavior is well known and need not be described here.

It may be useful to summarize previous observations of the Paschen lines. Laboratory observations of the first two lines m = 4, 5, λλ18751, and 12818 Å, by Paschen himself, using a bolometer, were reported in 1908. About fourteen years later, F. S. Brackett, working at Johns Hopkins University with a sensitive thermocouple constructed by A. H. Pfund, found 3 or 4 additional lines. The first photographs of Paschen series lines were made a few years later at Johns Hopkins by A. H. Poetker on neocyanin sensitized plates prepared by the Eastman Kodak Company. The lines λ10049 (m = 7) to λ8863 (m = 11) were included.

The first astronomical identification was the line λ10049 made by H. D. Babcock on his photographs of the solar spectrum and on the bolometer tracings of Abbot and Freeman. Babcock also suspected the presence of the preceding line λ10938 on the bolometric record. Recently, H. W. Babcock has found nine members of the Paschen series, λ9546 (m = 8) to λ8502 (m = 16) inclusive, as diffuse emission lines on spectrograms of the solar chromosphere made, without an eclipse, at the 150-ft. tower telescope of the Mount Wilson Observatory.

The first spectrograms to show these lines in stellar spectra were taken in June, 1932. Since then numerous photographs showing lines from λ8862 (m = 11) to λ8334 (m = 24) have been obtained. The appearance and general behavior of the Paschen lines in the various types of the stellar sequence is much like that of the corresponding Balmer lines. They are conspicuous in A-type spectra, especially in the "c" stars β Orionis and α Cygni.

The ionized calcium lines λλ8498, 8542 and 8662, like the related lines H and K in the violet, are prominent through a range of spectral type from A to M and constitute convenient landmarks in the near infra-red. The infra-red lines arise from a metastable D term and thus tend to exhibit, in absorption, the properties of ultimate lines. The general behavior in stellar spectra is therefore much like that of H and K, but some interesting exceptions occur. The facts suggest that among the hotter stars high luminosity enhances H and K with respect to the infra-red lines, while among red stars the reverse relationship holds.

The interval of spectral type through which the neutral oxygen line λ8446 and the triplet 7771–4–5 have considerable intensity is about A0–G0, but these lines appear very sensitive to absolute magnitude. They are more intense in α Cygni than in any other object photographed. The presence of these lines in emission in γ Cassiopeiae and P Cygni strengthens the correspondence between atmospheres of Be stars and the solar chromosphere.

Lines accentuated in the infra-red spectrum of α Cygni, possibly in consequence of the star's high absolute magnitude, are those of H, O I, N I, Mg II. These lines should prove valuable in the problems of high-luminosity stars of types B–G.

The region from 8320 to 8840 Å in spectra of classes K and M is dominated by lines of three elements, calcium, titanium and iron. Calcium is represented by the triplet of ionized lines, titanium and iron by numerous lines of the neutral atom. The only notable line not due to one of these three elements is λ8806 of neutral magnesium.

The characteristic bands in N-type spectra have, for many years, been ascribed to carbon or cyanogen. Identifications of additional cyanogen bands in the extreme red and infra-red have been brought out by recent photographs at Mount Wilson. It therefore seemed desirable to ascertain whether details of the complex stellar spectra, almost wholly unidentified except for band-heads, correspond with groups of individual band lines. For this purpose Dr. King kindly offered his photographs of furnace spectra, from which were prepared positive copies with the scale reduced to that of the stellar photographs. Direct comparisons of the stellar negatives with the laboratory positives yielded convincing evidence that a very large part of the extraordinary structure in N-type spectra between 6910 and 8780 Å may be attributed to absorption by cyanogen molecules. Many, and perhaps all, the apparently bright lines are only bits of continuous spectrum emerging through narrow interstices in the complex network of absorption lines. As Dr. Sanford has since found that this explanation is true also of the regions of shorter wave-length, the well-known difficulty experienced by previous observers in making chemical identifications of the narrow maxima as emission lines is understandable.

Time allows only a bare mention of the extremely interesting recent investigations of the infra-red spectra of the planets. Slipher, whose earlier work on the visual region of planetary spectra is well known, photographed conspicuous dark bands in the spectra of Jupiter and Saturn near 7920, 8400, 8615 and 8810 Å. His spectrograms extended beyond 10,000 Å. Observations by Adams and Dunham in the infra-red have revealed the presence of carbon dioxide on Venus, and, in confirmation of probable identifications by Wildt, of ammonia and methane on Jupiter and Saturn.

We now turn to longer wave-lengths which can not yet be photographed. It is not for lack of stellar energy, however, that the photographic plate is impotent. As Fig. 1 shows, the radiation of a low temperature star has far more energy per ångström between 10,000 and 20,000 Å than at the shorter wave-

lengths where photographs are taken with ease. This leads us to hope that in the near future emulsions sensitive far into the infra-red may be produced. Moreover, it is possible that photoelectric cells sufficiently sensitive to the infra-red for stellar observations may soon be developed.

For the present, however, we have recourse only to measurements made by means of so-called "non-selective" receivers that react equally to a given amount of radiant energy, no matter what its wave-length. This appears not to be true of any chemical or electronic process. It is well known, however, that all radiation falling on a dull black (non-reflective) surface is transformed into heat, and the resulting rise in temperature of the receiver is a measure of the intensity of the incident radiation. The problem thus resolves itself into detecting and measuring very small changes in temperature.

A very small blackened receiver at the focus of the 100-inch telescope on Mount Wilson may be heated as much as 0.°015 C. by the image of Betelgeuse. For fainter stars the measured increase in temperature is often but a few millionths of a degree.

These small temperature differences have been successfully measured by devices of three different types: (1) the thermocouple, (2) the bolometer, (3) the radiometer. In the thermocouple the heat is conducted from the receiver to a small area of contact between two suitable metals and there generates a minute electric current, which is measured with a sensitive galvanometer. In the bolometer, the change in electrical resistance of a small metal strip exposed to the stellar radiation is measured. The action of the radiometer depends upon the rotation of a delicately suspended vane, caused by the increased rebound of the molecules of the surrounding gas when one side of the vane is warmed by starlight. Measurements of stellar radiation by the three methods have been made by various observers as follows: The thermocouple—Pfund at Allegheny Observatory, Coblentz at Lick and Flagstaff Observatories, Pettit and Nicholson at Mount Wilson Observatory; the bolometer (originally developed by Langley for measurements of the solar spectrum)—Abbot at Mount Wilson Observatory; the radiometer—Nichols at the Yerkes Observatory, Abbot and Smith at Mount Wilson Observatory. The sensitivity of these three instruments, which measure the rise of temperature in entirely different ways, is nearly the same.

Investigation of stars with these instruments is still in the pioneer stage, but numerous significant results have already been obtained. Infra-red light plays an especially important rôle in the study of low-temperature stars, many of which are long-period variables. Ultra-violet light would be equally important in observations of high-temperature stars, were it not shut out by the earth's atmosphere.

Stellar radiation measurements show that, to a first approximation, the intensity of infra-red light from cool stars is that to be expected on black body theory if temperatures deduced from observation at shorter wave-length are correct. The effect on color- and heat-indices of departures from black-body radiation, due to band-absorption or other causes, should be carefully studied.

Pettit and Nicholson, measuring with a thermocouple the energy collected by the 100-inch telescope, have discovered certain remarkably interesting facts concerning the behavior of long-period variable stars. They found for six objects the mean range in total energy to be only 0.9 mag., whereas the visual range is 5.9 mag. In other words, in passing from minimum to maximum the brightness of these stars is multiplied by 230, while the total heat radiated is only slightly more than doubled. Pettit and Nicholson also found the energy maximum to occur 50 days (about one seventh of the cycle) later than the light-maximum, when the brightness has decreased by 1.5 magnitudes (*i.e.*, to one fourth of the maximum brightness). The importance of these facts in the study of long-period variables as immense gaseous globes of fluctuating brightness is obvious.

The same observers have obtained useful data by comparing the total radiation of a star with that transmitted by one centimeter of water which screens out radiation of wave-lengths greater than about 12,000 Å. For long-period variables at minimum light the water cell transmitted less than one seventh of the total energy.

Dr. C. G. Abbot in 1923 and 1928 employed radiometers in connection with the 100-inch telescope to make measurements of the intensity at various points in low-dispersion spectra of a few bright stars. Readings were made at nine wave-lengths from 4370 Å to 22,240 Å. The data were sufficiently accurate to outline the general form of the energy curve and to show the approximate position of its maximum. Dr. Abbot thought a tenfold increase in sensitivity would justify a long campaign of observations of spectral energy-distribution. Dr. Sinclair Smith has recently devised a modified technique, which may afford the desired improvement and thus make possible the determination of accurate energy curves of numerous bright stars. Investigations of this kind, combined with reliable spectrophotometric measurements by photoelectric cells or by photography, should in the near future greatly extend our present fragmentary knowledge of energy distribution in stellar spectra, and thus be of fundamental importance in the solution of many astrophysical problems.

OBITUARY

MEMORIALS

The Technology Review reports that this autumn friends and alumni of Victoria University College, New Zealand, undertook to commemorate in a series of portraits to be hung in the college library the work of their four foundation professors, of whom the late Dr. Richard C. Maclaurin, who later became president of the Massachusetts Institute of Technology, was one. Apprised recently of the plan, the corporation of the institute voted to present to Victoria College a copy of Frank W. Benson's oil portrait of Dr. Maclaurin, which now hangs in the president's office. The copy will be made by Leslie P. Thompson and will be sent to the college, where it will hang as a memorial to the earlier achievements of Dr. Maclaurin.

As a tribute to Dr. Frederick C. Shattuck, long a teacher in the Harvard Medical School, the name of Van Dyke Street, which adjoins the Medical School buildings, has been changed to Shattuck Street. As the street is a private thoroughfare, the change was made by authority of the Harvard Corporation and the neighboring hospitals. Dr. Shattuck graduated from Harvard College in 1868, and the Harvard Medical School in 1873. From 1879 to 1912, he was a member of the teaching staff at the Harvard Medical School, serving as Jackson professor of clinical medicine from 1888 to 1912. Following his retirement from active teaching, he was a member of the Board of Overseers from 1913 to 1919, and until his death in 1929 he remained actively interested in the progress and development of the Harvard Medical School.

A GRANITE shaft with bronze inscription commemorative of the work of Dr. W. C. Stubbs, erected by the American Sugar Cane League, was recently unveiled at the laboratory buildings of the U. S. Sugar Plant Field Station of the U. S. Department of Agriculture at Houma.

THE French Academy of Medicine at a recent session observed the one hundredth anniversary of the birth of Dr. Carlos Finlay, who discovered the mode of transmission of yellow fever.

A MEDALLION of bronze commemorating the late Dr. Alexander S. Monro, president of the Canadian Medical Association in 1931, was recently unveiled at the University of British Columbia. Dr. Monro bequeathed a substantial fund to the university for medical education when a medical school is established at the university.

Nature reports that on October 23 the Mayor of Lancaster, England, Mrs. A. E. Helme, opened the new technical workshops and craft rooms at Meeting House, and later formally opened the new Frankland Laboratory at the Storey Institute, Lancaster. The laboratory, which will be devoted to chemistry, was founded in memory of the late Sir Edward Frankland, the eminent chemist. Frankland was born at Churchtown in Lancashire in 1825, but at an early age went to live in Lancaster. He studied chemistry under Playfair, Bunsen and Tyndall, and after carrying out some research under Liebig at Giessen, was elected professor of chemistry at Owens College, Manchester. Later he worked in London at St. Bartholomew's Hospital, the Royal Institution and at the School of Mines. He was elected a fellow of the Royal Society in 1853 and in 1894 he was awarded the Copley medal. On January 18, 1933, the anniversary of Frankland's birth, it was proposed to found a Frankland Society in Lancaster. The proposal was adopted and the Lancastrian Frankland Society came into being with Professor H. E. Armstrong, Frankland's oldest living pupil, as president.

RECENT DEATHS

DR. HENRY STEPHENS WASHINGTON, petrologist of the Carnegie Institution of Washington, died on January 7 at the age of sixty-seven years.

DR. HOWARD CROSBY WARREN, head of the department of psychology at Princeton University, died on January 4, at the age of sixty-six years.

DR. RICHARD FROTHINGHAM, professor of otology and laryngology at the College of Physicians and Surgeons of Columbia University for thirty-five years, died on December 5. He was sixty-six years old.

DR. EDMUND M. BAEHR, professor of physiology at the College of Medicine of the University of Cincinnati, died on January 1 at the age of fifty-six years.

DR. LINSLY RUDD WILLIAMS, managing director of the New York Academy of Medicine, and president of the New York Tuberculosis and Health Association, died on January 7, in his fifty-ninth year.

DR. T. SWALE VINCENT, professor of physiology in the University of London from 1920 to 1930, died on January 1 at the age of sixty-five years.

DR. J. A. STEWART, emeritus professor of moral philosophy at the University of Oxford, died on December 27, at the age of eighty-seven years.

JAMES COSSAR EWART, professor of natural history at the University of Edinburgh for forty-five years, died on January 1, at the age of eighty-two years.

BARON ALPHONSE BERGET, professor at the Oceanographic Institute, Paris, died on December 29, at the age of seventy-three years.

SCIENTIFIC EVENTS

THE ROYAL SOCIETY AND HEAVY HYDROGEN

THE *Times*, London, reports that the rooms of the Royal Society were crowded on December 14 for a discussion on heavy hydrogen. This discovery, which was characterized as one of the most important of the present century, is of interest not only for physics and chemistry, but for botany, physiology and medicine.

Lord Rutherford, who opened the discussion, suggested the name diplogen for heavy hydrogen and the name diplon for the nucleus of the atom of heavy hydrogen. Hitherto the name deuterium has been used for the former, and deuton, or deuteron, for the latter. Lord Rutherford acknowledged that the name given by a discoverer was generally adopted by the scientific world, but he regarded the question as of great scientific importance in the case of heavy hydrogen, and thought that deutons were liable to be confused with neutrons—especially if one had a cold. As neutrons were involved in any discussion of heavy hydrogen, the question of confusion was very pertinent.

The president of the society, Sir F. Gowland Hopkins, invited speakers to express their opinion on this point. Dr. N. V. Sidgwick gave strong support to Lord Rutherford's terminology. He said he was present at the Chicago meeting when the discovery was announced, and terminology caused great difficulty. When a missing element was recently discovered, it did not matter much how it was called—"Florentinium" or "Mussolinium"—because they would come across it so seldom, but heavy hydrogen was another matter.

Dr. F. W. Aston also supported Lord Rutherford's terminology. He thought, from his remembrance of the Chicago meeting, when the discussion tended to become acrimonious, that the Americans would not take kindly to it. While there he spoke to Professor Bohr, who thought that as the substance was hydrogen it ought to be called hydrogen. Dr. Aston admitted that a discoverer was allowed to give a name to what he had discovered, but denied that the scientific public were under any obligation to use it. He instanced Uranus, which was originally called Georgium Sidus by William Herschel, and said that the word isotope and his own mass-spectrograph had changed in meaning since they were first put forward.

In the discussion on the properties of heavy hydrogen, Lord Rutherford gave details of a new diffusion process by which it has been obtained in small quantities without any trace of ordinary hydrogen. He also referred to the structure of the diplon, and said the most obvious suggestion was that it consisted of two protons and an electron, but it might consist of a proton and a neutron. He had bombarded heavy hydrogen with alpha-particles from polonium, and the neutrons obtained were only one per cent. of those obtained when beryllium was similarly bombarded.

Dr. Hartek exhibited specimens of ordinary water and heavy water, and illustrated the difference in their freezing points.

Professor F. Soddy said he wanted to protest as forcibly as he could against the description of heavy hydrogen as an isotope. He had not seen any evidence that we were not dealing with something like the difference between oxygen and ozone. He thought, however, that the discovery was a fundamental one.

A NATION-WIDE SURVEY OF FIRST-YEAR COLLEGE PHYSICS

A NATION-WIDE survey of the courses in first-year college physics, which promises to be one of the most comprehensive and important cooperative ventures ever attempted by the colleges and universities of this country, has been announced by the Committee on Tests of the American Association of Physics Teachers. The proposed program has been formulated jointly by a committee of the association and by two committees of the American Council on Education. It calls for the testing of students in the first-year course twice during the college year 1933–1934. The test forms will be furnished to participating institutions at cost.

In an article which appears in the December issue of *The American Physics Teacher,* Dr. Karl T. Compton, president of The Massachusetts Institute of Technology and chairman of the American Institute of Physics, makes the following comments with regard to the proposed survey:

> The plan of uniform, nation-wide tests in the first-year college physics appears to avoid the dangers inherent in most educational standardizing schemes, while retaining their advantages. It is reasonable that this new venture is but the first of a series which will stimulate interest in and improve the quality of the teaching of college physics.
>
> The plan seems to me to have distinct advantages, as follows:
>
> It will give each teacher a means of evaluating his own efforts and product, with the resulting opportunity of guided improvement. Yet it does this gently, since it does not make public the results by name of school or individual.
>
> Being unofficial and optional, it does not curtail the freedom of any school to set its own standards and give its own examinations in accordance with its own particular and local interests.
>
> As a sporting proposition it is "heads I win, tails you lose"; for if your school makes a fine showing, you can proclaim the fact from the house-tops, but if your record is low you can bury your shame and make a more intelligent effort to do better next time.

Speaking for the American Institute of Physics, I am sure that this new move will be generally approved and its broader educational results watched with interest. Meanwhile we solicit the wholehearted support of all physics teachers to make this venture as successful and valuable as possible.

The personnel of the committee is as follows: C. J. Lapp, *chairman,* University of Iowa; H. W. Farwell, Columbia University; Frederic Palmer, Jr., Haverford College; John T. Tate, University of Minnesota, and A. G. Worthing, University of Pittsburgh. Departments of physics wishing to participate in the survey can obtain complete details of the plan from any member of the committee, or from Dr. F. S. Beers, University of Minnesota, the secretary of the Committee on Educational Testing of the American Council on Education.

THE HAYDEN PLANETARIUM OF THE AMERICAN MUSEUM OF NATURAL HISTORY

A GIFT of $150,000 by Charles Hayden, of Hayden, Stone and Company, has been made to the planetarium to be constructed by the American Museum of Natural History's Planetarium Authority.

F. Trubee Davison, president of the museum, made public a resolution, adopted by the executive committee of the Planetarium Authority, that "in recognition of the public-spirited and generous offer of Mr. Hayden, the planetarium building shall henceforth bear the official title and be referred to as the Hayden Planetarium."

Mr. Hayden's gift is for the purchase of the planetary projection instruments and a Copernican planetarium, the latter being a reproduction of our solar system in scale models. The cost of the construction of the building to house the artificial firmament of stars, planets and constellations will be defrayed by a $650,000 bond issue to be purchased by the Reconstruction Finance Corporation. It is expected that the planetarium will open in the spring of 1935.

Although detailed construction plans have not yet been completed, the general scheme calls for a two-story-and-basement structure of brick and steel. The façade will be supported by six Grecian columns. On the outer surface of the dome, which will rise above the building, will be traced various stellar constellations, done in metal on a background of midnight blue. The dome will be made visible at night by indirect flood-lighting.

It will have a diameter of 75 feet, while the height of the chamber in the center will be 37½ feet. The horizon at the base of the dome will represent the skyline of New York in silhouette. There will be seats for 750 people.

While it is hoped that the planetarium will eventually be free to the public, an admission charge will be made until the money borrowed from the Federal Government has been paid. It is stipulated, however, that public school children attending in classes are to be admitted free at special periods.

The installation of the scientific equipment will be supervised by Dr. Clyde Fisher, curator of astronomy and education in the museum, who will also be in charge of the planetarium. Plans for the building are being completed by Trowbridge and Livingston, the museum architects.

The Hayden Planetarium will be the third of its kind in the United States and the twentieth in the world. Chicago had the first in this country and Philadelphia the second. Germany has twelve, Italy two, and Austria, Russia and Sweden one each.

EMERGENCY CONSERVATION WORK

OFFICIALS of the Emergency Conservation Work organization recently completed arrangements for adding between 30,000 and 40,000 new men to the Civilian Conservation Corps during the first ten days of the New Year as replacements for members of the corps who have been discharged to accept other employment or for other reasons.

The selection of new men has been virtually completed by state welfare agencies designated by the Labor Department, the regional managers of the Veterans' Administration and the technical representatives at the camps of the National Park Service and the Forest Service. The War Department began enrolling the men at the forest camps on January 2 on a schedule which called for completing the enrolment on January 10.

The program, as approved by Robert Fechner, director of emergency conservation work, calls for the enrolment of sufficient men to bring the strength of each of the 1,466 C. C. C. units up to a strength of 200 men each. When the replacement program is completed there will be approximately 240,000 young men, 35,000 experienced woodsmen and 28,125 war veterans in the corps, an aggregate strength of slightly above 300,000. This enrolment will be exclusive of the 12,000 Indians now enrolled in the Indian conservation camps.

Since initiation of the Emergency Conservation Work program on April 5, approximately 450,000 men have been enrolled and given jobs in the corps. Of this number, 296,000 are still at work in the forest camps. The balance has been discharged at various times to accept outside employment or for other reasons. Most of the men who left the corps were discharged at the end of the first six-months' period when President Roosevelt authorized continuance of the

camps until April 1. At that time all the men were urged to find outside employment if possible, so that their places in the camps could be taken by needy unemployed young men. Members of the corps are given honorable discharges on request if they find outside employment.

One hundred and twenty-five thousand new men were added during October and November to take the places of members of the summer C. C. C. camps who were discharged at or prior to the end of the first six-months' period.

FEDERAL APPROPRIATIONS FOR SCIENTIFIC WORK

IT is reported by Science Service that the new federal budget for the year 1934–35 just submitted to the Congress by President Roosevelt does not propose any substantial reduction in funds for scientific bureaus below the funds that were available for use during the present fiscal year.

Of the funds appropriated last year for use during the fiscal year 1933–34, approximately $34,768,000 was for the support of scientific research. But this sum was greatly cut by the Budget Bureau after the beginning of the Roosevelt administration. Figures appearing in the new budget volume indicate that only about $28,893,000 was actually allowed the bureaus for scientific work. A somewhat smaller amount for scientific research is allowed in the new 1934–35 budget for the fiscal year starting next July 1. Probably not more than $27,735,000 will be available for this purpose during the coming year. Most of the bureaus affected, however, have just as much as they did during the present year, or a little more.

The Bureau of Standards is allowed $1,437,702 instead of $1,336,000. The Bureau of Mines gets $762,926 instead of $694,985. The Naval Observatory gets $169,994 instead of $160,025. And other scientific bureaus or offices are given sums similarly close to the figures apportioned to them this year.

The main exception is the Department of Agriculture. Although this department is allowed under the budget greatly increased funds, these are mainly for administrative purposes and particularly for the carrying out of the recovery program. It is too early yet to know just what proportion of the total will be apportioned for research, but it is believed that not more than $15,700,000 will be devoted to this constructive work as against $18,000,000 available this year.

If the congress approves the budget as submitted, it will mean that scientific funds will be cut about 4 per cent. below the funds available for the present fiscal year, and 34.5 per cent. below the $42,375,000 spent on research during the fiscal year 1931–32.

AWARD OF THE PERKIN MEDAL TO DR. COLIN G. FINK

THE Perkin Medal of the Society of Chemical Industry was presented on the evening of January 5 to Dr. Colin G. Fink, professor of electrochemistry at Columbia University. The meeting was held jointly with the American Chemical Society, the Electrochemical Society and the Société de Chimie Industrielle.

The award was made several months ago by a committee representing five national chemical societies. This medal, a high honor in the chemical profession, is awarded each year for valuable work in applied chemistry and goes to Dr. Fink this year for his inventions in the fields of metallurgy and electrochemistry.

Dr. Fink's work was described by Professor Harold Hibbert, of McGill University. Presentation of the medal was made by Professor Marston T. Bogert, of Columbia University, who is a past president of the Society of Chemical Industry. Dr. Fink presented the customary medal address, his paper being entitled "Chemistry and Art," in which he discussed the seldom appreciated relationship between these two fields.

Dr. Fink's important inventions are in the fields of lead-in wires for electric bulbs, ductile tungsten, tungsten plating, insoluble anodes for copper refining, restoration of ancient bronzes, etc. He has been connected with the Metropolitan Museum of Art during the last eleven years. His work has been confined largely to the metals, but he has also worked with old marbles, paintings, porcelain and ceramic ware, ivories, lacquer work, etc. An interesting development is that all museum cases to-day at the Metropolitan Museum have a chemically controlled atmosphere.

Colin G. Fink was born in New Jersey in 1881. He graduated from Columbia College in 1903 and took the degree of doctor of philosophy at the University of Leipzig in 1907. He then joined the research staff of the General Electric Company at Schenectady, where he remained until 1917. In that year he became head of the new research laboratories of the Chile Exploration Company, New York. In 1922 Dr. Fink was called to Columbia University, where from that time he has been in charge of the division of electrochemistry.

THE ASSOCIATION OF AMERICAN GEOGRAPHERS

THE thirtieth annual meeting of the Association of American Geographers was held at Northwestern University, Evanston, Illinois, on December 26, 27 and 28. In the three-day session fifty-seven papers, including the presidential address, were presented before the association.

Out of the total number of fifty-seven papers thirteen can be classed as belonging to the field of

geomorphology. The last half day of the last session was devoted to papers on geomorphology. In this group should be included the address of the retiring president, Dr. François E. Matthes, of the U. S. Geological Survey, who spoke on "Our Greatest Mountain Range, the Sierra Nevada of California."

Six papers were devoted to urban geography. This interest in the geographical aspects of cities illustrates a feature of modern geographical field studies.

On Tuesday afternoon, December 26, one session was devoted to the general subject—"Conventionalizing Geographic Investigation and Presentation." Professor P. E. James, University of Michigan, presented a paper on "The Terminology of Regional Description." Professor W. D. Jones discussed "Procedures in Regional Investigation." The final paper of the group was given by Professor V. C. Finch, University of Wisconsin, on "Written Structures for Presenting the Geography of Regions."

Ten papers at least were strictly in the field of regional geography or chorography. In these there was evidence of the use of the techniques and terminology discussed in the symposium mentioned above.

A feature of the meeting was an address by Dr. L. Dudley Stamp, of the London School of Economics, who was an invited guest of the association. He spoke on the subject "One Hundred Years of Change in Land Utilization in the British Isles—the Work of the Land Utilization Survey of Britain." In this paper Dr. Stamp discussed not only the results of the survey but the method by which they are gradually completing a land use map of Britain on the scale of six inches to the mile.

For the forthcoming year the officers elected are: *President,* Dr. W. W. Atwood, president of Clark University; *Vice-president,* Professor V. C. Finch, University of Wisconsin; *Treasurer,* Professor R. S. Platt, University of Chicago; *Secretary,* Professor Frank E. Williams, University of Pennsylvania, and *Counselor,* Professor P. E. James, of the University of Michigan.

SCIENTIFIC NOTES AND NEWS

In conferring the degree of doctor *honoris causa* on Dr. Harvey Cushing in connection with the ceremonies marking the formal reopening of the University of Paris on November 4, Dr. A. Roussy, professor of morbid anatomy and dean of the faculty of medicine, said in part: "I render public homage not only to one of the greatest surgeons of the United States of America but also to the man whose work in anatomy, physiology and clinical surgery has brought great progress to modern neurology and to the ingenious inventor whose new forms of technique have made it possible, during the past thirty years or more, to save thousands of lives."

For the first time in 121 years the Connecticut State Medical Society on January 5 exercised its charter right to confer the honorary degree of doctor of medicine. The recipient was Dr. Russell H. Chittenden, professor emeritus of physiological chemistry and emeritus director of the Sheffield Scientific School of Yale University. The ceremony was a feature of the one hundred and fiftieth anniversary of the founding of the New Haven Medical Association. In conferring the degree, Dr. Ralph A. McDonnell, president of the state society, said: "This honor, now held by no living man, is about to be conferred upon you in recognition of your valuable contributions to our knowledge of the human body and because of the inspiration derived from your instruction by many who later achieved marked success in the practise of medicine."

At the meeting of the American Astronomical Society held at Cambridge from December 28 to 30, Dr. Albert Einstein was elected to honorary membership. There are seven other living honorary members.

On the occasion of the annual meeting of the National Council of Geography Teachers, the Distinguished Service Award was presented to Professor R. H. Whitbeck, of the department of geography in the University of Wisconsin. The award was established only a year ago and the first recipient was Dr. William M. Davis, professor of physiography, emeritus, at Harvard University. At the end of the present academic year Professor Whitbeck will complete twenty-five years of service at the University of Wisconsin.

At a ceremony in New Orleans on December 4, Dr. Rudolph Matas, since 1928 emeritus professor of surgery, Tulane University of Louisiana School of Medicine, New Orleans, was presented with the medal of the Order of Isabella the Catholic, the only Spanish decoration retained by the republic from the late monarchy; the presentation was made by the consul of Spain. The honorary degree of doctor of medicine and surgery was also conferred on Dr. Matas on this occasion, the consul-general of Guatemala making the presentation on behalf of the University of Guatemala. The mayor of New Orleans presided at the ceremony.

On January 23 the first Matas Award in Vascular Surgery will be presented in New Orleans to Dr. Mont R. Reid, from 1895 to 1927 professor of surgery at Tulane University, now professor of surgery at the University of Cincinnati.

DR. WILLIAM HALLOCK PARK, director of laboratories of the New York City Department of Health, celebrated his seventieth birthday on December 30. Among the gifts received was a bronze *bas relief* plaque. This was presented on behalf of the workers in Dr. Park's laboratory at a brief ceremony in the auditorium of Willard Parker Hospital by the retiring commissioner of health, Dr. Shirley W. Wynne, as his last official act. The plaque is the work of the sculptor Alexander Finta.

DR. J. MCKEEN CATTELL, editor of SCIENCE, was given a dinner at the University Club, Boston, at the time of the meeting of the American Association for the Advancement of Science. Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, presided, and Dr. John Dewey, emeritus professor of philosophy, Columbia University, made the principal address.

DR. WILLIAM E. PRAEGER, since 1905 head of the department of biology at Kalamazoo College, Michigan, has recently celebrated his seventieth birthday anniversary. Next June he will have terminated twenty-nine years of active service at Kalamazoo, primarily in the teaching of botany.

DR. LECOMTE DU NOÜY, head of the biophysical department of the Pasteur Institute, Paris, has been elected a member of the German Academy of Sciences at Halle, in recognition of his scientific work and in particular of his work on the physical and physico-chemical manifestations of immunity. Dr. Royal Whitman, of New York City, has been elected to membership in recognition of his work in orthopedic surgery.

E. F. REID has been awarded the Coopers Hill War Memorial Prize of the British Institution of Civil Engineers for 1932 for his paper on "Failures in Steel and Cast-Iron Mains and Provision for their Protection."

DR. R. ST. A. HEATHCOTE, lecturer in the University of Wales, has been decorated with the Third Class of the Order of the Nile, conferred upon him by the King of Egypt, in recognition of valuable services rendered by him as professor of pharmacology in the Egyptian Faculty of Medicine.

THE *Journal* of the American Medical Association states that special ceremonies in the School of Tropical Medicine of the University of Puerto Rico, San Juan, on December 16, marked the unveiling of a bronze bust of Dr. Bailey K. Ashford, who recently retired as a colonel of the medical corps, U. S. Army. The Honorable Benjamin J. Horton, acting governor of Puerto Rico, presented the bust to the School of Medicine, and Dr. George W. Bachman, director, made the speech of acceptance. Other speakers were Carlos Chardón, chancellor of the University of Puerto Rico, and Dr. Rafael Bernabe, president of the Medical Association of Puerto Rico. The casting of the bronze bust was unanimously approved by the legislature in recognition of the work of Dr. Ashford as founder of the School of Tropical Medicine and as initiator of the first campaign against hookworm disease in America.

DR. FRIEDRICH PASCHEN, Berlin, formerly president of the Physikalisch Technische Reichanstalt, and Dr. Arnold Sommerfeld, professor of theoretical physics at Munich, have been elected honorary members of the Physical Society, London.

DR. REGINALD RUGGLES GATES, professor of botany at Kings College, University of London, has been appointed a fellow of the college.

THE title of emeritus professor of eugenics has been conferred by the University of London on Dr. Karl Pearson on his retirement from the Galton chair of eugenics at University College, and that of emeritus professor of Egyptology on Sir Flinders Petrie on his retirement from the Edwards chair of Egyptology.

DR. CLARENCE KING has been appointed professor and head of the department of ophthalmology at the University of Cincinnati College of Medicine, to succeed Dr. Victor Ray, who has been made professor emeritus.

PROFESSOR RICHARD SIEBECK, of the University of Heidelberg, has been appointed to succeed Professor Wilhelm His in the chair of internal medicine and the directorship of the first University Medical Clinic.

The British Medical Journal states that the following German professors have resigned their appointments: Professor P. Wohlwill, professor of surgery at Hamburg; and Professor F. Janssen, professor of surgery, and Professor P. Neukirch, professor of internal medicine, at Düsseldorf.

OFFICERS of the American Society of Parasitologists have been elected as follows: *President,* E. E. Tyzzer, of Harvard Medical School; *Vice-president,* J. E. Ackert, Kansas State College; *Secretary,* H. W. Stunkard, New York University; *Treasurer,* J. Andrews, Johns Hopkins School of Hygiene. New council members elected at Boston are Dr. E. B. Cram, of the U. S. Department of Agriculture, and Dr. W. A. Sawyer, of the Rockefeller Foundation. The next meeting of the society will be held at Pittsburgh.

OFFICERS of the Entomological Society of America elected for 1934 are: *President,* C. L. Metcalf; *First vice-president,* E. P. Van Duzee; *Second vice-president,* J. H. McDunnough; *Secretary-treasurer,* H. B. Hungerford.

AT the annual meeting of the American Society of

Agronomy held in Chicago, Illinois, on November 16 and 17, the following officers were elected for the ensuing year: Professor R. I. Throckmorton, Kansas State College, *president;* Dr. H. K. Hayes, University of Minnesota, *vice-president;* Professor J. D. Luckett, New York State Agricultural Experiment Station, *editor,* and Dr. P. E. Brown, Iowa State College, *secretary-treasurer.* Professor Charles F. Shaw, of the University of California, was elected chairman of the soils section and Professor H. L. Westover, of the Bureau of Plant Industry, was elected chairman of the crops section. Professor R. M. Salter, of the Ohio State University, and Dr. J. G. Dickson, of the University of Wisconsin, were elected to the council of the American Association for the Advancement of Science, as representatives of the society.

AT the Philadelphia meeting of the American Association of University Professors the following officers were elected: *President,* Professor S. A. Mitchell, director of the Leander McCormick Observatory of the University of Virginia; *Vice-presidents,* Dr. H. W. Tyler, emeritus professor of mathematics at the Massachusetts Institute of Technology, consultant in science to the Library of Congress and general secretary of the association, and Dr. Yandell Henderson, professor of applied physiology at Yale University. Dr. W. W. Cook, professor of law at the Johns Hopkins University, was elected to succeed Dr. Tyler as general secretary.

OFFICERS for 1934 of the Royal Society of South Africa have been elected as follows: *President,* Dr. A. W. Rogers; *Treasurer,* Dr. L. Crawford; *General Secretary,* A. J. S. Goodwin; *Editor,* Professor R. S. Adamson; *Librarian,* Professor E. Newbery.

DR. CHESTER K. WENTWORTH, associate professor of geology at Washington University, St. Louis, has been granted an indefinite leave of absence to accept appointment as geologic engineer to the Honolulu Board of Water Supply. He will reach Honolulu early in February to undertake detailed geologic studies relating to the development of potential water supplies for the city of Honolulu.

DR. JEAN R. OLIVER, professor of pathology at the Long Island College of Medicine, has been assigned an additional grant of $1,000 by the Josiah Macy, Jr. Foundation for continued studies on the pathology of Bright's disease.

THE Committee on Scientific Research of the American Medical Association has made the following grants: to Dr. Harry B. Friedgood, for work on the therapeutic effects of various iodide compounds on experimental exophthalmic goiter in the guinea pig; to Dr. Carroll L. Birch, of the College of Medicine of the University of Illinois, for assaying urine of hemophiliacs and normals for the sex hormone of the anterior pituitary gland; to Dr. John L. Ulrich, to continue investigations on reciprocal action in the cat's nervous system. This work is being carried out in the department of zoology of the Johns Hopkins University.

AT the annual dinner of the Explorers Club, New York City, on January 6, F. Trubee Davison, president of the American Museum of Natural History, spoke on "Modern Exploration." Dr. Roy Chapman Andrews was toastmaster. Air Commodore P. F. M. Fellowes, leader of the Houston-Mt. Everest expedition last year, showed films taken on the flight over the summit. Bradford Washburn and Julien Bryan showed motion pictures on exploration subjects.

THE 1933 Marburg Lecture of the American Society for Testing Materials, which was delivered at the last annual meeting by Dr. H. J. Gough, superintendent, Engineering Department, National Physical Laboratory, England, on "Crystalline Structure in Relation to Failure of Metals—especially by Fatigue," has been published, and copies in separate form are now available. Dr. Gough, for over ten years, has carried out extensive experimental studies of metallic single crystals and he discusses in this lecture that section of the work concerned principally with the characteristics of deformation and fracture under mechanical forces.

THE Centennial Commission of the First and Second District Dental Societies of the State of New York announces the following to be awarded for suitable essays, at the discretion of the Prize Committee: A series of suitably engraved Centennial medals to each individual submitting the most acceptable paper, which paper embodies the result of original research or study not previously published, and must be between 2,000 and 5,000 words in length. In addition to the medals, the papers are eligible for: (1) The 1934 "Morris L. Chaim Prize" of the First District Dental Society of $250.00 offered for the most acceptable essay not previously published on research in dentistry or any of its specialties. The essay may also deal with the fundamental sciences, provided the work has a definite bearing on some dental problem. (2) The 1934 "Benjamin Lord Prize" of the First District Dental Society of $150.00 in the field of clinical dentistry, having an immediate and direct value to practical needs. (3) The "Frank T. Van Woert Prize" of the Second District Dental Society, of $100.00 for the best paper on "Dental History." (4) The "Thaddeus P. Hyatt Prize" of the Second District Dental Society of $100.00 for the best paper on "Preventive Dentistry." Further information may be obtained by addressing: The Centennial Dental Commission, Academy of Medicine, 2 East 103rd Street, New York City.

A NEW building which will serve as a laboratory for research in agricultural by-products will be built on the Iowa State College campus as soon as plans now in preparation are completed and bids for construction can be requested. Official word of the appropriation of $70,000 for the building by the Public Works Administration has been received from the U. S. Department of Agriculture at Washington, D. C., by T. R. Agg, dean of engineering, and P. Burke Jacobs, chief of the Ames Field Station. The money was allotted with the understanding that the building be placed under construction within the shortest possible time to provide immediate employment for about 50 men for approximately 6 months. Preliminary plans call for a structure about 35 feet high and containing about 60,000 square feet of floor space.

IN the furtherance of the oceanographic studies to which he has dedicated his steel cruiser, the *Velero III*, Captain G. Allan Hancock, of Los Angeles and Santa Maria, California, is undertaking his fourth cruise along the Pacific shores of North, South and Central America, and to a number of the adjacent islands. Among others, the Galapagos Islands are to be revisited to fill in certain gaps in the collecting of the previous cruises by Captain Hancock in those waters. The expeditionary staff comprises Captain G. Allan Hancock, director and captain; Mr. W. Charles Swett, executive officer and cinematographer; Dr. E. O. Palmer, physician; Dr. C. McLean Fraser, of the University of British Columbia, hydroids and other coelenterates; Dr. Harold W. Manter, of the University of Nebraska, representing the Carnegie Institution of Washington, trematode parasites of fishes; Dr. Wm. Randolph Taylor, of the University of Michigan, marine algae; Dr. Waldo L. Schmitt, of the Smithsonian Institution, crustacea, and Mr. John S. Garth, of the University of Southern California, ornithology and entomology. It was expected the expedition would sail from Los Angeles about December 30, and would be in the field for a period of two months or more.

DISCUSSION

ARE THERE GRANITIC AND BASALTIC SHELLS IN THE EARTH?

GEOLOGISTS at the present time seem to be gradually accepting the theory that the surface materials of the earth consist, in general, of a thin and incomplete layer of sediments over a thicker, but also incomplete, shell of granitic and gneissic material, which in turn overlies a probably thicker and continuous shell of basaltic (and peridotitic?) material. The incomplete shell of granitic material has been named the Sial, and the complete shell of basaltic material has been called the Sima.

It seems worth while to call attention to the fact that data now available suggest an explanation of this arrangement of the earth's near-surface materials (Sial and Sima), and, in fact, seem to require such an arrangement. The significant data are the following:

First: It has long been known that basaltic rocks are heavier than granitic rocks, and it is now well established that this is true at all temperatures and pressures found within the earth-zone in question, whether the substances are solid or liquid.

Second: Granitic rocks contain about twice as much radium as basaltic rocks. Considerable variations exist in different regions, but comparable measures nearly always disclose more radium in granitic rocks than in basaltic rocks of the same region, and, in general, the granites and rhyolites contain at least twice as much radium as the gabbros and basalts.

Third: Under normal conditions in the earth rhyolitic magmas crystallize at lower temperatures than basaltic magmas; in fact, after a careful study of all the data, Larsen[1] concluded that most rhyolitic magmas crystallize between 600° and 700° C., while most basaltic magmas crystallize between 800° and 900° C. Therefore, there is a difference of 200° C. between the average temperatures of crystallization of these two types of magmas.

Fourth: The measured geothermal gradient indicates that temperatures increase steadily (though not at a uniform rate) with increasing depth, and it is reasonable to infer that near-fusion temperatures exist in the earth at moderate depths. The existence of volcanoes proves that fusion temperatures exist, at least locally.

Fifth: The study of igneous rocks in the field and in the laboratory proves that differentiation is an important process affecting all kinds of magmas. There is much difference of opinion regarding the explanation of the process, but its existence and importance are no longer questioned.

Sixth: There are numerous minor and peculiar products of differentiation, but the two normal and abundant end-products of the process are rocks of the granitic and basaltic types.

The relation between these facts and the existence of a (partial) shell of Sial above the shell of Sima deserves careful attention. The facts seem not only to explain, but also to require, such an arrangement of earth materials. Perhaps the simplest way to

[1] *Am. Mineral.*, xiv: p. 81, 1929.

make this clear is to describe conditions and processes in the earth as determined by these facts.

If it be assumed that the earth's surface materials, to a considerable depth, at some time were not divided in zones or shells, but were approximately homogeneous, would they continue to be homogeneous indefinitely? No change is to be expected in the uppermost part, if it remains below fusion temperatures, but at some depth earth temperatures due to the normal geothermal gradient will be near fusion temperatures for the average rock materials. The radium present in the rocks will slowly raise the temperatures, since rocks are such good thermal insulators that heat will not be conducted away as fast as radioactivity produces it. Selective fusion of some parts is probable without the aid of heat derived from radioactive processes. After liquefaction (of any considerable mass) the magma thus produced will be lighter than the surrounding rocks and, even without fractures, it will therefore move slowly toward the surface. One mode of motion will be by means of rock flowage, in the same way that a balloon moves in the air, except that the motion is very much slower. After a time the magma will reach a cooler level and begin to crystallize; then (and perhaps before) differentiation will take place, leading to a gradual development of a more acid part and a more basic part. The level reached by the magma as a whole may be such that the basic part, perhaps produced by settling of the early products of crystallization, remains solid, while the acid part may remain liquid, because its crystallization temperature is about two hundred degrees lower than that of the basic part (if differentiation has produced a granitic fraction). Accordingly, the acid part will be slowly forced to a level still closer to the surface; and this process will be aided by the fact that the radium content of the original magma will be unequally divided between the differentiation products in such a way that the acid part will contain about twice as great a percentage as the basic part. Accordingly, the cooling effects of adjoining solid rocks will be more efficient in lowering (or preventing the rise of) the temperature of the basic part than in lowering the temperature of the acid part.

Ever since the beginning of the Paleozoic era such processes have affected the surface of the earth only locally—but even in this way a considerable fraction of the earth's surface has been subjected to the process. However, during the Precambrian the surface was affected more generally, so that the results of the process are to be found everywhere over the exposed Precambrian areas.

It is worthy of note that, once a mass of granitic composition is forced upward into the Sial shell, it is impossible for it to return to the underlying Sima. For, if such a mass, by subsidence or otherwise, is gradually buried toward the level of the Sima, it will liquefy at a level considerably above the basaltic substratum, since its fusion temperature is about 200° below that of the Sima, and the latter is believed to be near its fusion temperature.

Also, no granitic mass (or possible granitic differentiate) can long remain in the Sima, because, even if the Sima is not liquid or vitreous, it is believed to be at near-fusion temperatures, at which the granitic mass would be liquid and would therefore be forced toward the surface, since it would be considerably lighter than the surrounding Sima. Furthermore, such a granitic mass would contain about twice as much radium as the surrounding Sima, and would therefore gradually become hotter than the latter; so that, even if the upper part of the Sima is at a temperature level in some parts of the earth at which granite does not melt, the granitic mass would be further heated by its own radioactivity, and thus finally melt. On account of marked differences in specific gravity granitic magmas can not remain in the Sima.

It is true that, at least since Precambrian time, basaltic masses can remain indefinitely at the surface, but in the deeper and hotter portions of the earth an arrangement of rock materials controlled by gravity, and aided by radioactivity, differentiation and fusion temperatures, seems inevitable in the light of our present knowledge of the significant data on these subjects.

Such an arrangement corresponds well with the fact that seismic data require the existence of two (or more) shells with different properties near the earth's surface.

This paper has benefited by suggestions kindly offered by Professors R. A. Daly and C. K. Leith.

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COPPER IN RELATION TO CHLOROPHYL AND HEMOGLOBIN FORMATION

IT is known that chlorophyl, the respiratory pigment of plants, and hemoglobin, the respiratory pigment of the red blood cells of animals, are related chemically. One point of difference, however, is that magnesium is the element in chlorophyl corresponding to iron in hemoglobin. Under certain conditions the amounts of these pigments are decreased. A diet deficit in iron, for example, will cause a decrease in hemoglobin producing a condition known as anemia. Orange growers in Florida have recognized for a number of years that when citrus fruit trees are set on certain types of grove land—marl, for example—the leaves of the trees, instead of developing the characteristic deep green color, become spotted yellow, a

condition known as "frenching." This "frenching" in trees is evidently comparable to anemia in animals. Whether "frenching" can be produced by a deficiency in magnesium in the soil comparable to the production of anemia in animals by a deficiency of iron in the diet is not known, so far as I am aware. It is known however that copper sulfate is an effective remedy for "frenching" in citrus fruit trees. When Bordeaux mixture was first used as a spray material it was observed that in addition to its insecticidal property it caused the leaves of the citrus fruit trees to turn green and put on new growth. It was soon found that this beneficial effect was due to the copper in the Bordeaux, so that copper sulfate, or bluestone, has come to be used very extensively by Florida orange growers as a remedy for "frenching."

The object of this investigation was to determine the effect of copper sulfate on the chlorophyl content of "frenched" orange tree leaves, and the following is a description of the method of procedure in carrying out the investigation. Four pounds of commercial copper sulfate, or bluestone, were scattered on the ground in a Florida orange grove around several three-year-old orange trees, whose leaves had lost most of their green color or were "frenched." In the same part of the grove several other trees whose leaves were similarly "frenched" were left untreated for controls. Four months later chlorophyl determinations were made, using the photoelectric method described by Oltman,[1] and it was found that the leaves of the trees treated with the copper sulfate contained 4.6 times more chlorophyl than did the leaves of the control or untreated trees. It should be said in this connection that the copper sulfate greatly improved the general condition of the trees. They put on much new growth and the leaves turned green, while the untreated trees put on very little new growth and the leaves remained spotted yellow or "frenched." It should also be stated that the chlorophyl of the leaves from the treated as well as the untreated trees were analyzed for copper and none was found.

Hart, Steenbock, Waddell and Elvehjem[2] were the first to show that the presence of copper, although in minute quantities, was necessary for the utilization of iron in the formation of the hemoglobin of the red blood cells of the rat, and the experiments reported in this paper would seem to indicate that copper is likewise necessary for the formation of the chlorophyl of the leaves of orange trees, thus indicating a similarity between the animal and plant kingdoms in this respect. It should be mentioned in this connection that cattle grazing on certain types of Florida pasture land develop a nutritional anemia or "salt sickness," just as citrus fruit trees set on certain types of grove land develop "frenching" and this may be cured with the use of iron and copper.

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[1] R. E. Oltman, "A New Method and Instrument for the Quantitative Determination of Chlorophyll," *Plant Physiology*, 8: 2, 321–326, 1933.

[2] E. B. Hart, H. Steenbock, J. Waddell and C. A. Elvehjem, "Iron in Nutrition. VII. Copper as a Supplement of Iron for Hemoglobin Building in the Rat," *Journal of Biological Chemistry*, 77: 797–812, 1928.

THE INCIDENCE OF COLOR-BLINDNESS AMONG THE CHINESE

GARTH'S report in SCIENCE[1] of "The Incidence of Color Blindness among Races" is of considerable interest in showing that unselected white males are afflicted with color-blindness more than any one of the other racial groups reported on, *viz.*, Jews, North American Indians of various tribes, Mexicans and Negroes.

For comparison the following results obtained in an investigation of Chinese students in Chengtu may be of interest. Ishihara's color-blindness tests were used, and each chart was shown to a small group of students at one time. Each student was asked to write down the figure he saw. The students' papers were then collected and compared with the correct answers. In this way in a comparatively short time a large number of students were tested. All were males and ranged in age from students in primary schools to those in university.

Of 1,115 students 67, or 6.3 per cent., were found to be red-green blind, either complete or incomplete.

The only other report on the color-blindness of the Chinese of which we are aware is that of Chang,[2] in which he reports 80 out of 1,164 male students, or 6.9 per cent., to be deficient in color vision (either red-green blind or weak in color discrimination). In addition, he reports that 19 females out of 1,132 examined, or 1.7 per cent., showed either color-blindness or color weakness.

If these two reports are combined we have a color-blindness incidence of 6.5 per cent. for Chinese males, based on the use of the Ishihara test on a total of 2,279 students in the schools of Peiping and Chengtu, and an incidence of 1.7 per cent. for Chinese females, similarly tested on 1,132 girls in the schools of Peiping.

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[1] T. R. Garth, "The Incidence of Color Blindness among Races," SCIENCE, 77: 333, 1933.

[2] S. P. Chang, "Statistics on Color Blindness among Students in Peiping," *National M. J. China*, 18: 806, 1932.

THE RAMAN SPECTRUM OF HEAVY WATER

THE Raman spectrum of 80 per cent. heavy water obtained with a sample supplied by Professor Taylor, of Princeton, when compared with the spectrum of the 18 per cent. material previously reported, shows that the water molecule with two atoms of heavy hydrogen gives a Raman band with a frequency difference of 2517, while the molecule with one atom of heavy and one of light hydrogen gives *two* bands, one of frequency difference of 2623, the other of 3500. Ordinary water gives a band with frequency difference 3445. A single photograph of a sample of given concentration does not bring out this shift as the bands overlap, but by superposing the two photographs taken with different concentrations the shift in the center of gravity of the bands comes out in a very striking manner.

Preparations have now been made for photographing the spectrum of the vapor in which case we shall doubtless find double lines in place of the superposed and slightly shifted bands.

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THE JOHNS HOPKINS UNIVERSITY
JANUARY 2

REPORTS

WORK OF THE NEW YORK BOTANICAL GARDEN

SIGNIFICANT new activities of the New York Botanical Garden are noted in the annual report of the director to the Board of Managers which met on January 8. These include an exhibit during 1933 of plants for home aquaria, which will continue for two or three months more in the Museum Building, and the issuing for the first time of a seed list, making possible exchange of desirable species of plants with other institutions.

Through its new seed list, the garden is offering to botanical institutions throughout the world 500 species and varieties of plants, some native, some exotic and a number of them never before available from such a source.

In the greenhouses the most striking development of the year, according to Dr. Merrill, has been the naturalistic planting of the succulents in Conservatory Range 1, giving those interesting plants which are built to store water during long periods of drought an indoor rock-garden effect for a background.

Other changes still in progress, affecting the collections of ferns, cycads, aroids, bromeliads, bananas, begonias and orchids, are tending also to make the plants appear as though growing in their native haunts, rather than formally displayed in pots or tubs. The special display house for flowering plants in their season, inaugurated a year ago, has been continued this winter, and has attracted many hundreds of additional visitors to the conservatory.

Dr. Merrill emphasized the importance of the science course given for professional gardeners—including some of the gardening employees of the institution—calling it "the most significant innovation in the field of public instruction during the history of the garden." First- and second-year classes are now being attended by about 125 men and five women whose actual employment as gardeners over a period of years has entitled them to enrolment in the course. Such fundamental subjects as plant physiology and classification, chemistry, plant diseases and soils and fertilizers are being given. This course, started in the fall of 1932, is the first one of its kind to be given in America.

About two thirds of the Thompson Memorial Rock Garden, being constructed over more than two acres of ground in the glade east of the Museum Building, is now completed, Dr. Merrill reported, and a portion of this, having been planted last fall, will be blooming for the first time in the spring. Several thousand additional plants are now being raised in the propagating house, to be set out in the new rock garden in a few months.

Three thousand seedlings of rhododendrons and azaleas are also being grown at the garden, to be used eventually for bordering the walks and drives throughout the grounds.

The outdoor plantings of daffodils, iris, roses, peonies, cannas, dahlias and chrysanthemums, of which there are special displays each year, have all been increased in 1933. And the perennial border presented to the garden by the women of the Advisory Council has been most satisfactorily maintained.

The plantings of daylilies (Hemerocallis) and of Louisiana iris have been extended. In addition, a display planting of species and varieties of Hemerocallis has been created. Next summer it is hoped to have the first flowers from seedlings of hybrids of Louisiana iris.

Gifts of plants made to the Botanical Garden during the past year include rare shrubs and rock garden plants from the Boyce Thompson Arboretum; 140 orchid plants from George Baldwin and Company; cuttings of Erica, Calluna, Sedum and other genera from Clarence Lewis; 47,600 tulip and hyacinth bulbs for next spring's display from the Dutch Exporters' Association; cuttings of 140 species and varieties of conifers from the Arnold Arboretum and from Colonel Robert Montgomery; palms and cycads, also from

the Montgomery estate; 500 rose bushes from Bobbink and Atkins; 700 packets of seed selected and purchased by Stanley Ranger, and cannas, iris, dahlias, chrysanthemums, peonies and other plants for display purposes from a number of growers.

Gifts of money included $3,140 for the permanent endowment, $410 for current expenses and $1,942 for restricted purposes.

The library, which is the largest combined horticultural and botanical library in America, now numbers 43,429 bound volumes, of which more than 1,000 were added in 1933.

SCIENTIFIC APPARATUS AND LABORATORY METHODS

AIDS IN THE STUDY OF DENTAL CARIES WITH ALBINO RATS

RECENT reports[1] on the study of dental caries in the rat indicate that in such studies macroscopic examinations of the teeth were made only at autopsy. It is obvious that periodical examinations of the teeth made while the animal is still alive would be very advantageous, as then the course of the lesion could be followed.

Such observations have been carried out in this laboratory for the past two years, using the following procedure: The assistant holds the rat as indicated in the diagram (Fig. 1). With the rat grasped and

FIG. 1.

held in this position there is no danger to the assistant or the observer. The observer, wearing a Murphy head light and a Beebe binocular loupe, holds a pair of 3½ inch blunt forceps in each hand. Assuming that the left side of the rat's mouth is to be examined, the observer opens the animal's mouth by using the forceps in the right hand. The forceps in the left hand is now used to pull out the rat's tongue gently. The forceps in the right hand is now used to push the left cheek of the animal aside, thus permitting examination of the teeth on the upper and lower jaws. For observations on the opposite side this process is, of course, reversed.

The question of inorganic elements in blood serum in relationship to dental caries has also assumed importance recently.[2] It is, of course, desirable in such studies to obtain the maximum amount of serum in order to permit accurate determinations.

We have used the following modification of the method described by Kramer and coworkers:[3] With the animal lightly anesthetized by ether, the skin is removed from the neck region by cutting with scissors.

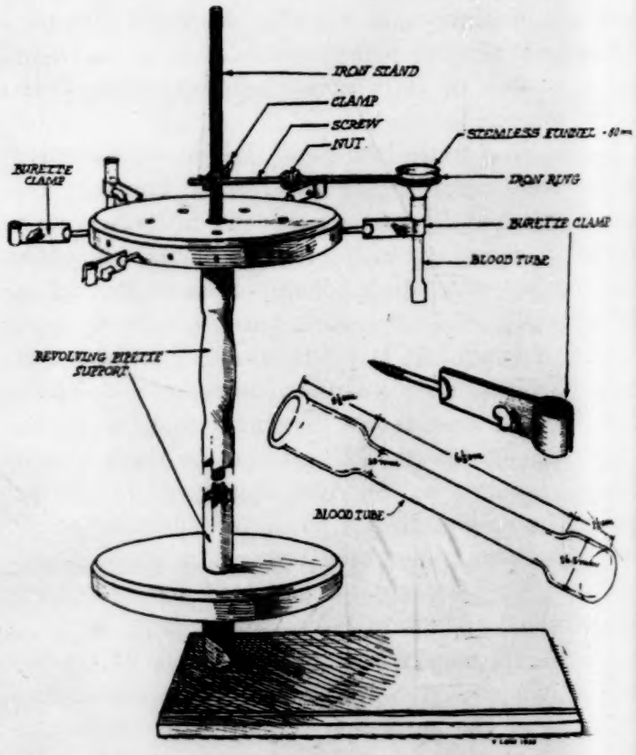

FIG. 2.

[1] H. Klein and E. V. McCollum, *Jour. Dent. Res.*, 13: 69, 1933; M. C. Agnew, R. G. Agnew and F. F. Tisdall, *Jour. Amer. Dent. Assoc.*, 20: 193, 1933; D. E. Shelling and D. E. Asher, *Jour. Dent. Res.*, 13: 363, 1933.

[2] H. Klein and E. V. McCollum, SCIENCE, 74: 662, 1931; M. C. Agnew, R. G. Agnew and F. F. Tisdall, *Jour. Amer. Dent. Assoc.*, 20: 193, 1933; D. E. Shelling and D. E. Asher, *Jour. Dent. Res.*, 13: 363, 1933; I. Neuwirth and P. Brandwein, *Jour. Dent. Res.*, in press.

[3] B. Kramer, M. J. Shear and J. Siegel, *Jour. Biol. Chem.*, 91: 271, 1931.

Using forceps, the muscles in the neck region are separated in the mid-line until the trachea is exposed. The internal carotid artery is now isolated and a ligature passed under it. The animal is now held head downward and, using the ligature as a guide, the artery is cut and the blood permitted to flow into the tube as shown in the arrangement in Fig. 2. We have found that the tube illustrated permits obtaining more serum than is ordinarily possible in the average centrifuge tube.

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THE SILVER IODIDE TEST FOR HYDROCYANIC ACID

IT is not infrequently desirable to ascertain the presence of hydrocyanic acid in faint traces, with the use of a delicate, fairly rapid and simple test. The ready recognition of this compound is of use occasionally to agriculturists, toxicologists, health officials, fumigators of ships and buildings, and to the coroner, as well as to numerous scientific investigators engaged in various types of work.

Recently the writer has had occasion to make tests for traces of HCN in connection with current studies of cyanogenetic glucosidases present in certain marine organisms. With the cooperation of Dr. C. E. ZoBell of this institution, a number of marine bacteria and fungi are being studied with reference to the capacity of these forms to hydrolyze the cyanogenetic glucoside amygdalin. Similar studies are being made of the alimentary tracts of certain marine invertebrates.

Guignard's test, which consists of the suspension of sodium picrate papers over the solution or culture under investigation, is very delicate, but according to the numerous writers, not highly specific for HCN. This test, however, is employed as a preliminary one in our laboratories to indicate the presence of free HCN in various microorganism cultures or enzyme systems. If the compound is present, the bright yellow color of the alkaline picrate paper is converted, through various stages of yellow-orange, orange and red orange to the brick color of the reduced compound, sodium picramate.

In order to confirm the presence of HCN, and to demonstrate that it, and not other substances, is responsible for the reddening of the papers, an additional delicate and specific test has been developed, based, in principle, upon the quantitative method for determining HCN described and used by Roe[1] and later by Bishop.[2] This method, used in determining the amount of HCN present in certain leaves, kernels, and pure cyanogenetic plant glucosides, consists in aerating the solution containing the digest, and conveying the air thence into dilute potassium hydroxide to catch all of the HCN, aeration being continued until all of the compound has been carried over. The alkaline cyanide solution is finally titrated for CN^-, using the general method of Liebig, with very dilute silver nitrate solution, employing potassium iodide as an indicator. With proper lighting and a black background the end point can be determined very sharply as the first permanent faint cloud of AgI appears, indicating that all of the CN^- has been taken up in forming the complex salt potassium argenticyanide $KAg(CN)_2$.

The procedure used in our own work, for confirming the presence of HCN indicated by Guignard's test, consists in a modification, perhaps better termed an inversion, of Roe's method.

To a thoroughly cleaned test-tube are added first one drop of 5 per cent. KI solution, and one drop of .001 M $AgNO_3$ (solutions as dilute as .00025 M can be used if only the faintest traces of HCN are suspected), and then one cubic centimeter of 5 per cent. KOH solution. A faint bluish cloud of AgI is now present. Air is drawn through the system or culture which is being tested for HCN, and thence into the alkaline silver iodide suspension. If HCN is present, the KCN formed dissolves the AgI, rendering the solution perfectly clear. The test is specific for HCN, since H_2S, NH_3, HCNS (NaCNS), and other bacterial catabolites were found to exert no visible effects upon the silver iodide, which is soluble only in such non-volatile compounds as $Na_2S_2O_3$, NaCl, etc. It is important that the reagent be prepared freshly for each test, since AgI does not remain in the colloidally dispersed condition described under the circumstances for longer than a day at most. The limit of delicacy is about 1 part HCN in 2,000,000, when .00025 M $AgNO_3$ is used under ordinary laboratory conditions. Without doubt the perception of even fainter clouds of AgI with the use of special nephelometric instruments would render the test still more delicate.

An attractive feature of this method, besides its specificity, delicacy and simplicity, is that, should a positive test for HCN be found, quantitative determination of the compound can be made forthwith if desired by merely continuing the aeration without altering the system or interrupting the process, thus making use of the chemical method perfected by Roe.

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[1] J. H. Roe, "The Estimation of the Hydrogen Cyanide Content of Amygdalin by the Aeration Method," *Jour. Biol. Chem.*, 58: 667, 1924.

[2] L. R. Bishop, "The Estimation of Cyanogenetic Glucosides," *Biochem. Jour.*, 21: 1162, 1927.

SPECIAL ARTICLES

THE METHOD OF PROBITS

THE result of an investigtion of the action of a toxic agent upon the mortality of an organism is usually expressed as an asymmetrical S-shaped curve, in which the percentage mortality of each set of individuals is related to the dosage to which it has been exposed (Fig. 1). The effectiveness of a poison used

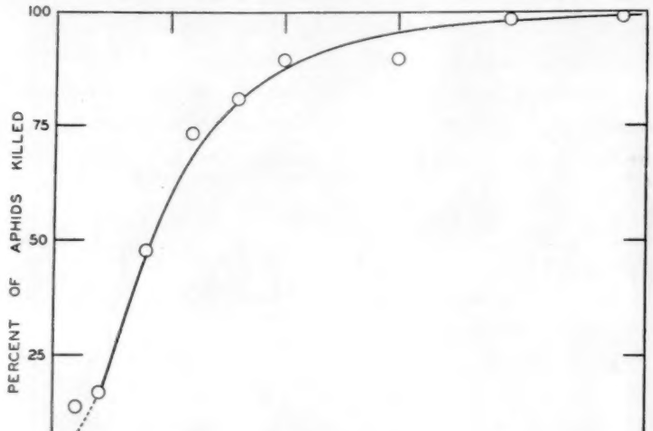

FIG. 1. Net mortality of *Aphis rumicis* L. sprayed in laboratory with different solutions of nicotine; summary of results over 3-year period. Tattersfield and Gimingham.[4] Heavy curve is same as that in Fig. 2 transposed back to original units.

to combat an insect pest is of primary interest to the economic entomologist in the range of dosages approaching 100 per cent. kill. But in this region, the usual type of curve flattens to an asymptote, so that comparisons are commonly based upon dosages which kill only from 25 to 75 per cent. of the organisms. Furthermore, the curve is ordinarily fitted free hand, and in instances where the data are more or less irregular, there is a tendency to adjust the usually asymmetrical S-curve to successive small segments of the data rather than to the observations as a whole. This practise introduces an indeterminate distortion due to the experimental errors and to unconscious bias on the part of the experimenter. It is believed that these and other difficulties can be minimized if percentage kill and dosage are transformed to units which may be plotted as straight lines on ordinary cross-section paper and hence permit fitting by the customary technique of least squares or of the straight-line regression equation.

A survey of the literature revealed that an inherent variability among individuals of a population in their susceptibility is considered to be responsible for the S-shaped character of the curve.[1] With any dosage to which some individuals succumb while others survive, the poison kills not only those which would survive any smaller amount, but also those more susceptible individuals which could be killed with a smaller amount. Because of this inherently cumulative character, the type of curve just discussed has been termed by Shackell[2] the "dose-effect ogive." So many different types of variation in a great variety of organisms have followed the symmetrical normal curve of error that the variation in resistance to poison might be expected to follow suit. Instead of assuming that the observed asymmetry in this case is due to a skewed distribution of errors, an explanation of the asymmetry has been sought in the mode of toxic action. When dosage is plotted directly on an arithmetical scale, the cumulative S-curve could be symmetrical only if equal additions in dosage at all concentrations resulted in equal increments in lethal action. It has been observed in many physiological processes that equal increments in effect are produced only when the stimulus is increased by a constant proportion of the given dosage, rather than by a constant amount. It seems probable that this same rule might hold for toxicological processes, in which case dosage would have to be plotted in logarithmic terms to show a uniform increase in kill or a symmetrical dose-effect ogive.

Of the different methods which might transform a dosage-mortality curve to a straight line, if the above analysis is a valid one, two offer advantages. By the first method, cross-section paper might be so ruled that a relationship involving the two functions, the cumulative curve (as ordinate) and logarithms (as abscissa), would plot as a straight line. Paper with rulings for a symmetrical cumulative curve and logarithms has been devised by Whipple and Hazen,[3] and can be purchased on the market. Because of greater ease in determining the straight line of best fit by the simple regression equation, the present author has found it more convenient to use a second method, to transform the data instead of the paper to the appropriate units. The transformation of dosage presents no difficulties, since tables of logarithms are universally available. For the percentage kill, no equally simple and direct system of transformation was at hand. The nearest approximation was offered by the tables of the probability integral, Nos. I and II in Part I of Pearson's Tables for Statisticians and Biometricians. The principal table (No. I) had the disadvantage of an origin at .50 (or 50 per cent.) and thus involved the use of plus and minus quantities. This difficulty has been avoided by a special table derived from those of Pearson by letting the observed 0.01 per cent. kill equal 0.00 on an arbitrary scale, 50.0 per cent. kill equal 5.00, and 99.99 per cent. kill equal 10.00, and then calculating

[1] S. C. Brooks, *Jour. Gen. Physiol.*, 1: 61, 1918.

[2] L. F. Shackell, *Jour. Pharm. and Exper. Therap.*, 25: 275, 1925.

[3] G. C. Whipple, *Jour. Franklin Inst.*, 182: 205, 1916.

TABLE I

Per cent. kill	Probits	Per cent. kill	Probits	Per cent. kill	Probits	Per cent. kill	Probits
1.0	1.87	50.0	5.00	80.0	6.13	95.0	7.21
5.0	2.79	52.0	5.07	81.0	6.18	96.0	7.35
10.0	3.28	54.0	5.14	82.0	6.23	97.0	7.53
15.0	3.61	56.0	5.20	83.0	6.28	98.0	7.76
20.0	3.87	58.0	5.27	84.0	6.34	98.5	7.92
25.0	4.09	60.0	5.34	85.0	6.39	99.0	8.13
30.0	4.30	62.0	5.41	86.0	6.45	99.1	8.18
34.0	4.44	64.0	5.48	87.0	6.51	99.2	8.24
36.0	4.52	66.0	5.56	88.0	6.58	99.3	8.30
38.0	4.59	68.0	5.63	89.0	6.65	99.4	8.38
40.0	4.66	70.0	5.70	90.0	6.72	99.5	8.46
42.0	4.73	72.0	5.78	91.0	6.80	99.6	8.57
44.0	4.80	74.0	5.86	92.0	6.89	99.7	8.69
46.0	4.86	76.0	5.95	93.0	6.98	99.8	8.87
48.0	4.93	78.0	6.04	94.0	7.09	99.9	9.16

the intermediate values in a symmetrical manner. These arbitrary probability units have been termed "probits" and are given above in an abbreviated table.

The method just described for the analysis of toxicological curves has been applied successfully by the author to a large series of data from the literature, as well as to unpublished records secured by himself or his associates. An example of this transformation is that of the curve in Fig. 1 into that shown in Fig. 2. Aside from an increased accuracy in calculating dosage-mortality curves and in interpolating dosages from such curves over a more extended range of mortalities than has been practicable with the usual asymmetrical S-curve, this type of presentation has led to the following advantages: (1) a test of the proposed theory of toxic action that (a) the variation in susceptibility among individuals is normal, and that (b) the effectiveness of the dose increases as its logarithm; (2) a closer scrutiny of experimental technique to determine if the organisms

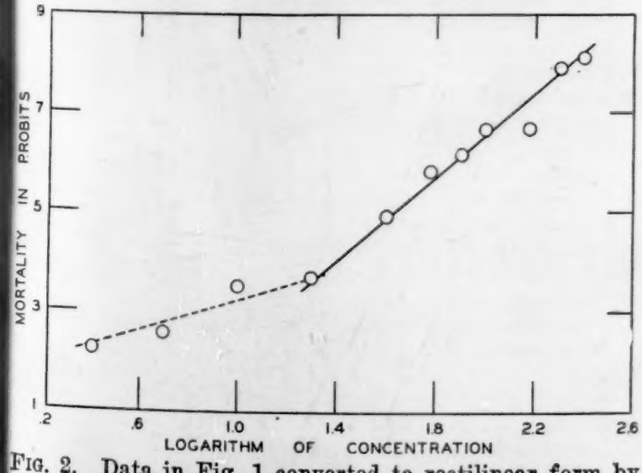

FIG. 2. Data in Fig. 1 converted to rectilinear form by use of logarithms and probits as explained.

exposed to each dosage were truly equivalent and if the amounts administered experimentally were uniformly proportional to the effective dosage over the entire range covered by the experiment; (3) the disclosure of change in the mode of lethal action with certain poisons over different sections of the dosage range, indicated by an abrupt change in slope as illustrated in Fig. 2; and (4) a simple method of expressing, in the slope of a straight line, the relative uniformity or diversity between individuals in their susceptibility to a poison.

The experimental records from the entomological literature to which this theory has been applied successfully include such diverse cases as the action of nicotine sprays upon aphids,[4] of several fumigants upon adult Tribolium,[5] of hot water upon Japanese beetle pupae,[6] of x-rays upon Drosophila eggs,[7] and of acid lead arsenate upon fourth instar silkworm larvae.[8] A more detailed table of probits and a more extended consideration of insect toxicological tests will be presented later.

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OXIDATION-REDUCTION REACTIONS BETWEEN NATURAL HYDROCARBONS AND OIL-FILLED WATERS

As far as known to the writers, it was G. S. Rogers who first pointed to certain constant relations between the occurrence of sulphide and sulphate waters on the one hand and of the composition of the associated petroleums on the other.[1] Rogers suggested that this relation might be interpreted as indicating that sulphate waters were reduced to sulphide waters by petroleums with paraffin as a base, the latter at the same time becoming oxidized and polymerized so as to yield naphthene or asphalt bases. Subsequently Bastin and his associates demonstrated that certain bacteria may serve as agents in such or similar changes and it may well be suggested, on the basis of Bastin's experimental evidence, that at moderate temperatures bacterial action is not only a sufficient but a necessary cause.[2]

In 1928 and 1930 Colacurcio and Bengtson,[3] at the

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suggestion of the senior author of the present paper and under the direction of Professor E. F. Farnau, of the University of Cincinnati, carried out experiments bearing on this hypothesis. Briefly summarized, these experiments suggested that sulphates could be reduced to sulphides at temperatures of approximately 150° C., and thus within the ranges anticipated in oil fields on the basis of the geothermal gradient but above the probable viability of bacteria.

Colacurcio, after autoclaving the reagents to kill bacteria, used potassium, calcium, and magnesium sulphates and obtained reduction with the aid of sulphide-free West Virginia paraffin-base crude petroleum. He employed iron bombs, cadmium chloride as indicator, temperatures ranging from 85° to 250° F., and periods varying from 1 to 24 hours. Though positive results were obtained at the elevated temperatures mentioned, room temperatures for periods of as much as two months gave negative results only.

Bengtson used longer periods, glass bombs, and strip silver as a more delicate indicator. In the main his results also were positive, the sulphate reduction being most pronounced in the presence of ferrous sulphate and of clay as catalysts. His governing temperatures ranged up to 257° F. and his periods were chiefly three days long. Negative results only were obtained at temperatures approaching those of the room despite increases in time up to a total of seven days. The oil was Pennsylvania "crude."

The purpose of this brief notice is two-fold. First, it is desired to present the results of the experiments described above in abstract, in view of their obvious bearing upon the possible derivation of "asphalt"-base petroleums from those with paraffin as base; especially is this summary desirable because of the fact that the results have never been available to students of the subject. Second, the present authors take this occasion to announce the fact that they are now essentially repeating and extending the experiments of Colacurcio and Bengtson with the aid of a furnace constructed to maintain slightly higher but static temperatures for several months at a time. They will vary (a) temperatures and pressures within the ranges known or estimated to exist in present reservoir rocks, (b) the paraffin compounds used, confining themselves, however, to simple paraffin group members in place of complex natural petroleums, (c) the oxidizing agents, and (d) the catalysts which might occur in nature, such as colloidal silica and "kaolin."

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ON A SCURVY-LIKE DISEASE IN CHICKS

HOLST and Halbrook recently reported[1] that in the course of nutritional studies on baby chicks they observed the development of a "scurvy-like" disease the symptoms of which they say are nervousness and lameness, external and internal hemorrhages, bones often brittle and extremely low hemoglobin content of the blood. A cure was said to be effected by feeding five grams of cabbage per bird.

In an attempt to confirm the observation of Holst and Halbrook, three lots of twenty-five day-old Leghorn chicks each were placed on the following diets. Lot 101 was fed the Holst-Halbrook diet, the formula of which was kindly furnished us by Everett R. Halbrook, consisting of fish meal, 20.5 parts; ground yellow corn, 49.5 parts; ground whole wheat, 25 parts; air-dried yeast, 2 parts; ground oyster shell, cod liver oil and salt, 1 part each. Lot 102 received the above diet, except that autoclaved yeast was substituted for 8 parts of yellow corn and for the air-dried yeast. Lot 103 received the Holst-Halbrook diet, except that meat scrap meal was substituted for the fish meal.

At the end of eight weeks no symptoms of vitamin deficiency had been observed in any of the chicks. When the growth data were given statistical treatment it was found that lots 102 and 103 showed significantly better growth than the Holst-Halbrook lot, lot 102 showing the best growth.

No attempt is made to explain the observations of Holst and Halbrook; however, a "scurvy-like" disease could not be reproduced, and better growth was obtained by adding autoclaved yeast to the diet.

The authors are indebted to Professors J. S. Hughes and H. M. Scott for assistance in this study.

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